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13. ABSTRACT (Maximum 200 words)

Through support of this grant, a number of research projects on vortex dynamics and rarefied gas dynamics were completed. A few of the most outstanding results were the following: (1) An analytic theory for singularity formation on the fluid interface in the Rayleigh-Taylor problem was developed and shown to agree with numerical results, (2) Singular solutions were found by direct computation for Moore's approximation of the 3D Euler equations for axi-symmetric flow with swirl, (3) Generic form of singularities for hyperbolic and elliptic equations were classified using catastrophe theory. The results were applied to shock waves, vortex sheets and (in preliminary work) patterns in convective flows, (4) A careful set of controlled numerical experiments were performed for quasi-Monte Carlo methods, clarifying the sensitivity of this method to smoothness of the integrate and dimension of the integration domain, and (5) Standard Monte Carlo methods, such as acceptance-rejection, Feynman-Kac integrals and diffusion Monte Carlo, were modified to increase smoothness and decrease dimension so that quasi-random sequences could be used effectively.

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FINAL TECHNICAL REPORT
AFOSR Grant 90-0003
Analysis and Computation for Vortex Dynamics and Rarefied Gases

Russel E. Caflisch, PI
Mathematics Department, UCLA

November 29, 1993

Through support of this grant, a number of research projects on vortex dynamics and rarefied gas dynamics were completed. A few of the most outstanding results were the following:

- An analytic theory for singularity formation on the fluid interface in the Rayleigh-Taylor problem was developed and shown to agree with numerical results.
- Singular solutions were found by direct computation for Moore's approximation of the 3D Euler equations for axi-symmetric flow with swirl.
- Generic form of singularities for hyperbolic and elliptic equations were classified using catastrophe theory. The results were applied to shock waves, vortex sheets and (in preliminary work) patterns in convective flows.
- A careful set of controlled numerical experiments were performed for quasi-Monte Carlo methods, clarifying the sensitivity of this method to smoothness of the integrand and dimension of the integration domain.

- Standard Monte Carlo methods, such as acceptance-rejection, Feynman-Kac integrals and diffusion Monte Carlo, were modified to increase smoothness and decrease dimension so that quasi-random sequences could be used effectively.

Two graduate students received their Ph.D.'s under support of this grant. William Morokoff received his Ph.D. from the Courant Institute, NYU, in 1991. After an Industrial Postdoctoral Fellowship at the IMA and Siemens Corporation, he is now an NSF Fellow at the University of Arizona. Bradley Moskowitz received his Ph.D. at UCLA in 1993 and is staying at UCLA as a postdoc for a year. Both Morokoff and Moskowitz worked on quasi-Monte Carlo methods.

Funds from this grant were also used to support several postdocs and visitors, including William Morokoff, Bradley Moskowitz, David Pugh and Giovanni Russo.

Publications Supported by This Grant

1. "Singularities for Complex Hyperbolic Equations" Russel Caflisch, 1990 Lectures in Complex Systems, vol. III, ed. L. Nadel and D. Stein, Santa Fe Institute (1990) 471-479.

2. "A Nonlinear Approximation for Vortex Sheet Evolution and Singularity Formation," Russel Caflisch and S. Semmes, Physica D 41 (1990) 197-207.

3. "Quasi-Monte Carlo Methods for Numerical Integration and Simulation" William Morokoff (1991) Ph.D. Thesis, NYU.

4. "Analysis for the Evolution of Vortex Sheets," Russel Caflisch, Lect. Appl. Math., 28 (1991) 67-83.

5. "Multi-Valued Solutions and Branch Point Singularities for Nonlinear Hyperbolic or Elliptic Systems" Russel Caflisch, N. Ercolani, T. Hou and Y. Landis, Comm. Pure Appl. Math. 46 (1993) 453-499.

6. "Singularity Formation during Rayleigh-Taylor Instability" G. Baker, Russel Caflisch and M. Siegel, J. Fluid Mech. 252 (1993) 51-78.

7. "Singularity Formation for Complex Solutions of the 3D Incompressible Euler Equations" Russel Caflisch, Physica D, 67 (1993) 1-18.

8. "Quasi-Monte Carlo Integration" Russel Caflisch and W. Morokoff, J. Comp. Phys., submitted.

9. " A Quasi-Monte Carlo Approach to Particle Simulation of the Heat Equation" Russel Caflisch and W. Morokoff, SIAM J. Num. Anal. to appear.

10. "Quasi-Random Sequences and Their Discrepancies" Russel Caflisch and W. Morokoff, SIAM J. Sci. Stat. Comp. to appear

11. "Application of Quasi-Random Sequences to Monte Carlo Methods" Bradley Moskowitz (1993) Ph.D. thesis. UCLA.

Publications Supported by Previous AFOSR Grants that Appeared During this Period

1. "A Numerical Study of Riemann problem Solutions and Stability for a Viscous Conservation Law of Mixed Type" M. Affouf and Russel Caflisch SIAM J. Applied Math. 51 (1991) 605-634.

2. "A Localized Approximation for Vortical Flows" Russel Caflisch, O. Orellana and M. Siegel SIAM J. Applied Math. (1990) 1517-1532.